Effects to EBIS solenoid field from peripheral irons

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M. Okamura

1. Designed field.

According to a report numbered as 1605-BP-4660 issued by ACCEL, coil dimensions and operating currents are indicated as follows.

Main coil: ID 130 x 2 mm, OD 161.5 x 2, length 1635.52
End coils: ID 130.8 x 2 mm, OD 201.5 x 2 mm, length 106.34 mm
Distance between main coil and each End coil is 34.57 mm
Total coil structure length 1971.34 mm
0.7 mm OD round conductor operated at 76.6 A
Main coil has 2200 x 48 turns and each End coil has 140 x 100 turn.

Using above values, the current densities in the coils are estimated.

Main coil: 8088960 A turn, 154.798 A/mm2
End coil: 1072400 A turn, 142.640 A/mm2

TOSCA gave a field shape as Fig. 1 and this is different from the provided field distribution in the ACCEL report.

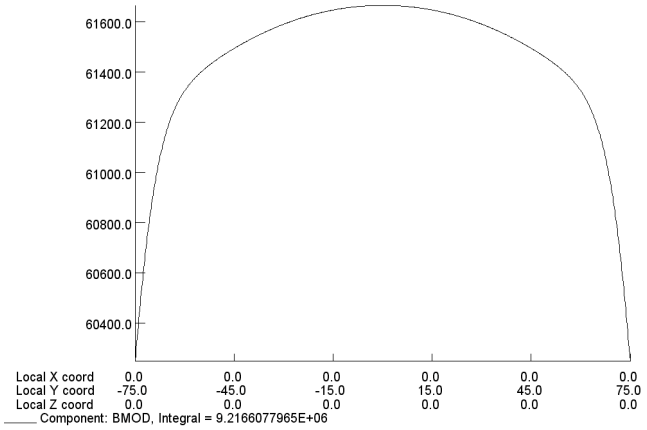

Fig. 1 Reconstructed field shape from the values indicated in the report.

After adjusting current densities in the coils keeping the same dimensions, TOSCA showed the field as in Fig. 2.

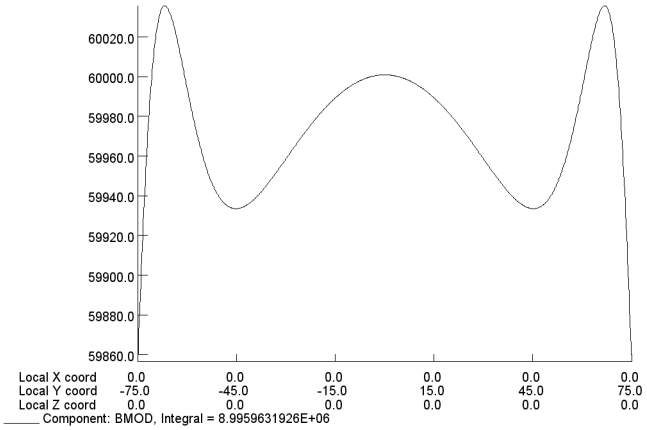

Fig. 2 Adjusted field shape to represent similar shape given in the report.

The used current densities are 150.52 A/mm2 (Main coil) and 149.90 A/mm2 (End coil).
There is still small difference from the field shape described in the report especially at the center of the magnet region which might contains current leads or a quench heater.
In these calculations, thermal contraction was not taken into account.

2. Effect from rails under the magnet structure.

In the calculation, two 1.0 x 1.0 x 300.0 cm rails are located at 41 cm beneath of the beam center (vertically -41.0 to -42.0 cm) and 33 cm apart from horizontally (33 to 34 cn) as shown in Fig. 3. The used material property of the rails are default iron's provided by the TOSCA. You can see that most of the all rails are highly saturated. The field components along the axis are shown in Fig. 4.

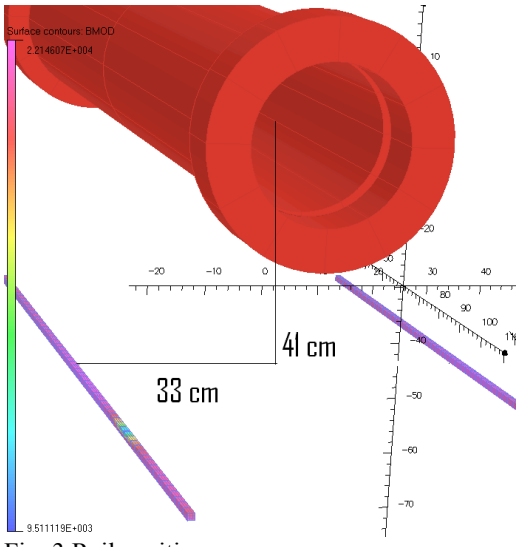

Fig. 3 Rail position

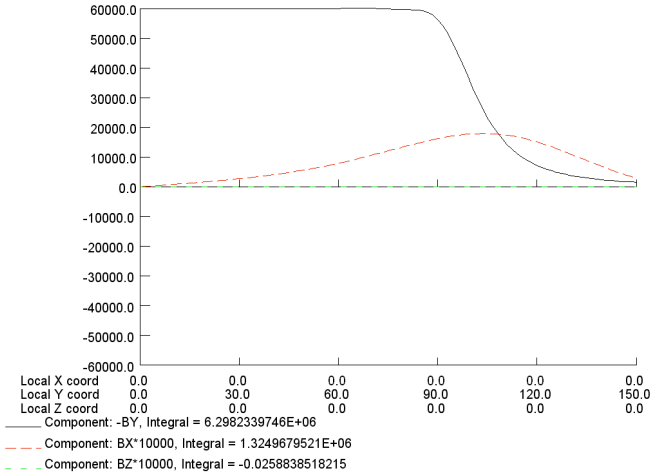

Fig. 4 Field distortion caused by the rails (in gauss)

In the Fig. 4, the red dashed line is magnified 10000 times. At exit of the coil, the vertically directed field is roughly 2 gauss. If rail cross section is lager, the distortion is expected to be larger.

3. Effect from shields of vacuum pumps.

For easier calculation, a cube shaped shield is assumed.

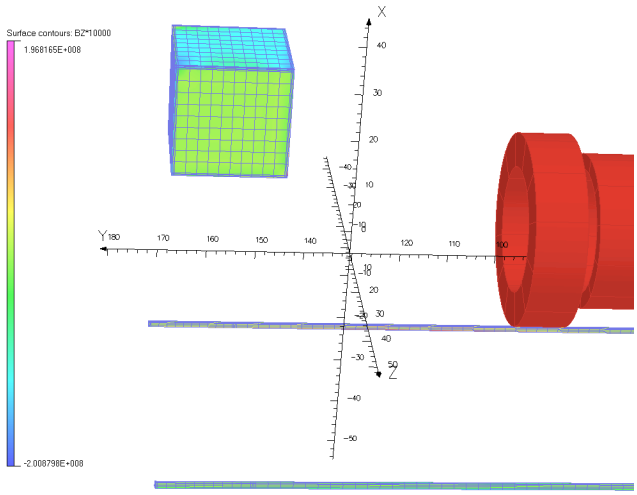

Fig. 5 Cube shield

The size of the cube is 20 x 20 x 20 cm. The position is;

Longitudinal: 150 to 170 cm from the magnet center,
Horizontal: 35 to 55 cm,
Vertical: 35 to 55 cm.

The calculated result is shown in Fig. 6.

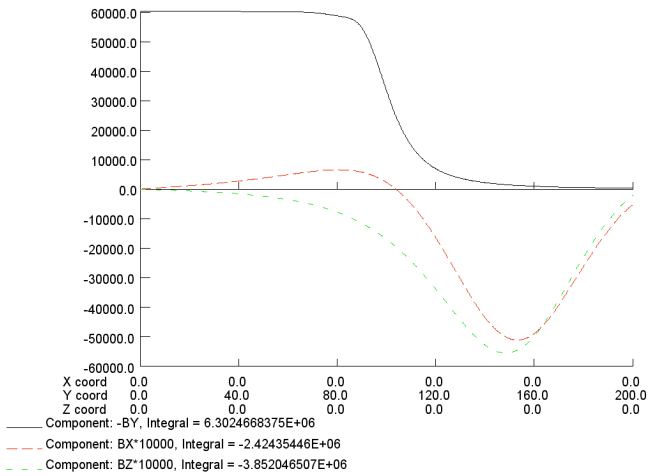

Fig. 6 Three components along the axis.

Inside of the shield, the field strength is about 50 to 60 gauss, assuming 5 mm thickness of the shield wall (Fig. 7). Assuming 2 mm thickness of the wall, the field in the shielded volume is increased a few hundred gauss level. A quarter inch thickness shield is recommended for this size and position.

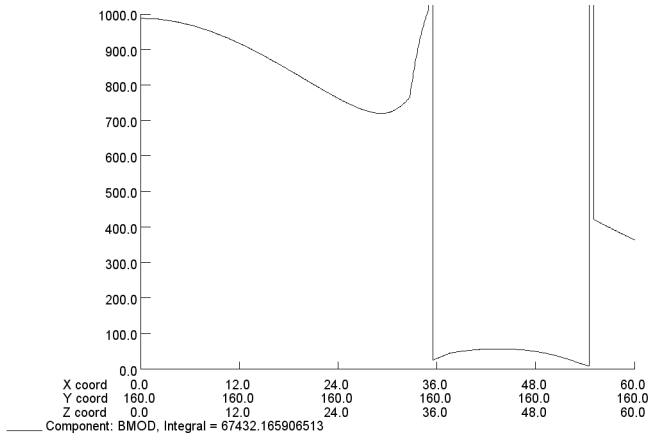

Fig. 7 Shielded field – 5 mm case.

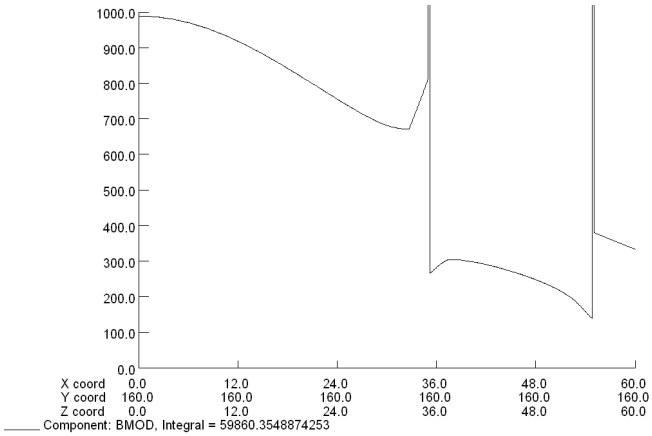

Fig. 8 Shielded field – 2 mm case.